Sem 4: Chemistry Honours

Zone Refining

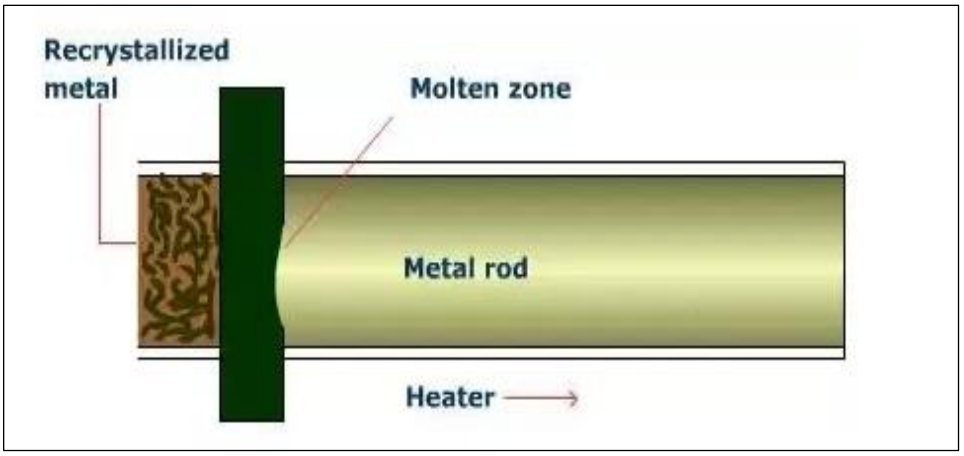
Zone refining is a very useful method to get metals with very high purity such as silicon and germanium. It is also referred to as zone melting, floating zone process, and traveling melting zone.

- What is Zone Refining?

Zone refining refers to the method of purifying a crystal wherein a thin region of the crystal undergoes melting. This 'molten zone' is now moved across the crystal.

The impurities in the metal are melted at the forward edge by the molten zone and move through the block of metal, leaving the solidified pure element behind.

As they move through the block of metal, the impurities in the metal are concentrated in the melt and are transported to one end of the metal block. An illustration for such a process is provided below.



- Principle of Zone Refining

The principle of zone refining is that the impurities in an ingot or ore of metal are more soluble in the melt state when compared to the corresponding solid state of the impurities.

In the zone refining process, the impurities are concentrated at one end of the block of metal so that the rest of the block is purified. It can be noted that the segregation coefficient (which is defined as the ratio of impurity in the solid state to the impurity in the liquid or melt state) is generally less than 1.

This implies that when the conditions are set at the solid-liquid boundary, the atoms of the impurity tend to diffuse into the liquid region.

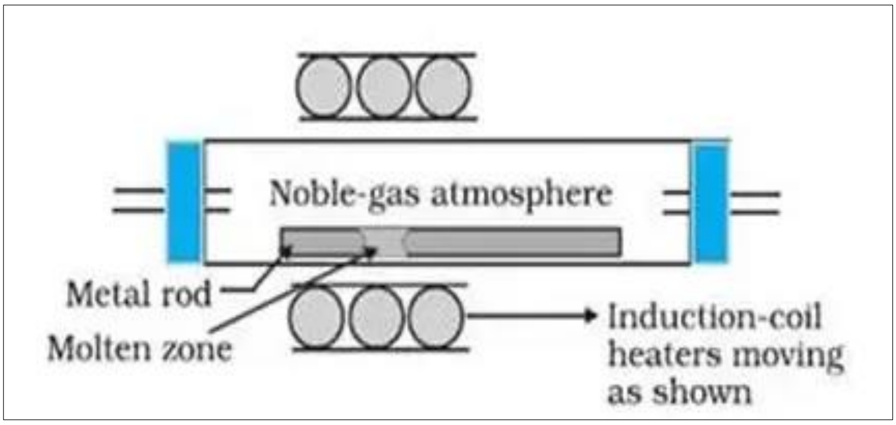
Zone Refining Process

In the zone refining process, a circular mobile heater is fixed at one end of the metal rod which is made up of the impure metal. Now, the circular mobile heater is moved slowly across the metal rod.

The metallic impurities melt at the temporary position of this heater. The melt containing the impurities moves forward along with the heater through the entirety of the metal rod. The pure metal is left to solidify as the heater moves along the rod.

As the heater moves forward, the concentration of the impurities in the melt increases. This is because the impurities are more soluble in their corresponding melt state. Finally, the impurities are accumulated at one end of the metal rod.

The process described above is repeated many times in the same direction. The end of the rod in which the impurities have now accumulated in is cut off, leaving behind the pure metal. An illustration of this process is provided below.

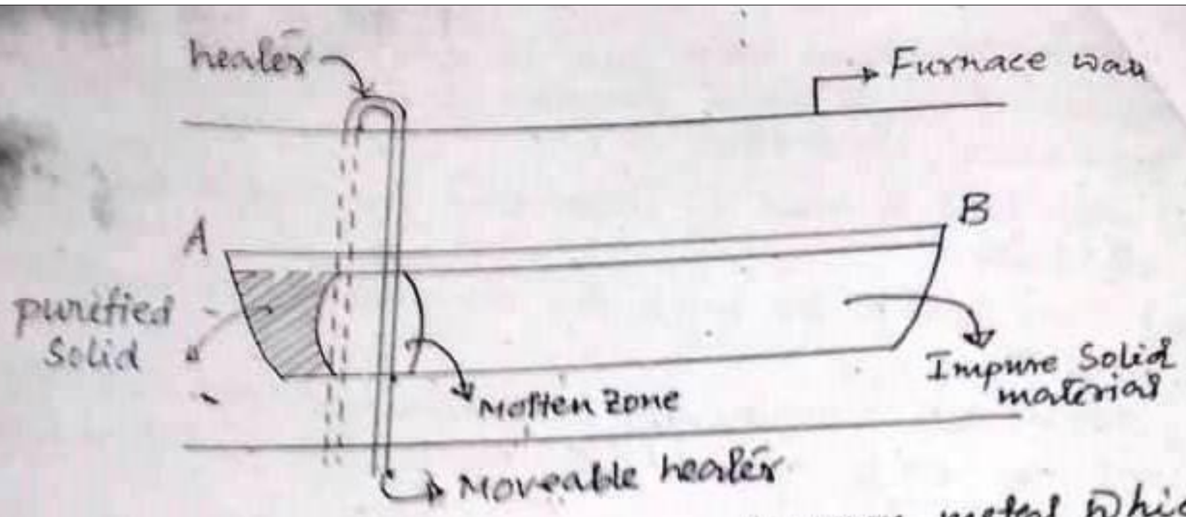


Thus, the required purified form of the metal is obtained. This process is very effective in the removal of impurities from semiconducting elements such as Germanium, Gallium, and Silicon. This process is also used in refining high-purity metals.

Zone Refining

This is a highly effective technique used for removing traces of impurities from nearly pure metals. The principle of this process is based on the theory of fractional Crystallisation.

In this process the Substance to be purified is taken in the form of a narrow cylinder and is heated in a narrow, disk like zone which is swept from one end of the sample to the other end. Immediately in front of the heater, the solid melts forming a liquid zone which carries more impurity provided it has a lower melting point. As the heater moves forward this liquid zone also moves forward and immediately at the back of the heater, we get a solid which carries lesser of impurity. The liquid zone as it moves forward becomes more and more enriched in the impurity as it is preferentially partitioned into the liquid phase. One pass of the heater from one end of the substance to the other may have the effect of reducing the impurity content only slightly. In order to get rid of more and more of impurity, the heater is passed repeatedly from one end to the other.



Case-I : let us Consider an impure metal which contains 'B' as impurity and 'A' as the desired pure metal. Let the m.p. of B < A. Then the temp$\underline{r}$ - Composition diagram is shown in fig-I. Suppose that the composition of the impure sample corresponds to the point 'P' with concn of 'A' 80% and B 20%. When the sample is heated, the first melt produced will have a composition 60% of B corresponding to the point 'O'. Obviously more impurity B has passed into molten state. By repeating the process of heating, most of the 'B' will be removed and will accumulate at the end 'B' (above picture).

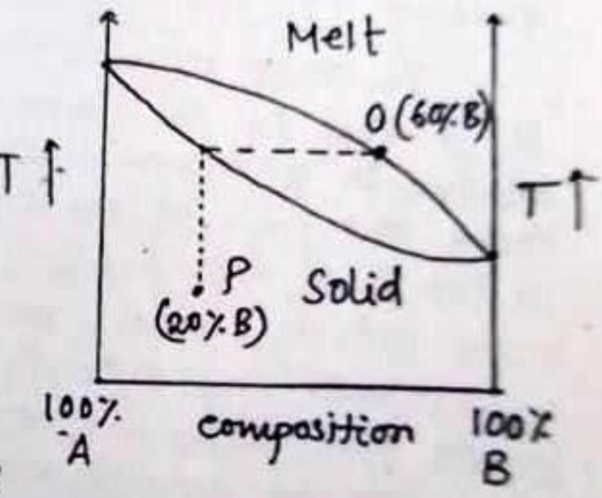


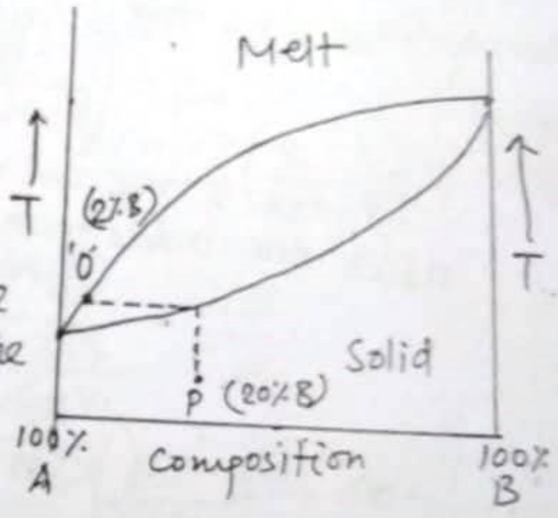
Fig-I

Case-II : Now suppose m.p. of B > A. In this case the impurity B will have higher concn in Solid than in the melt hence it would accumulate at the end 'A'.

'B' in the impure sample = 20%.
'B' in the melt after first heating = 2%.

This shows that impurity diminishes in the bar after repeating the process.

In both the cases, the value of distribution Co-efficient will decide the number of zone passes i.e. how many times the heater should be moved along the bar.



References: 1. https://byjus.com/chemistry/zone-refining/

2. K..L. Kapoor, Volume 3, Page 291, 4th Edition.

Submitted By

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